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SELF-LUMINOUS NIGHT HAZE.

By E. E. BARNARD.

(Read April 21, 1911.)

There is one phase of the night skies which does not seem to have received much or any attention. It is the occasional presence of self-luminous haze. This matter does not seem to be similar to the luminous night clouds, "die leuchtenden Nachtwolken," which were observed by O. Jesse and others some twenty-five or thirty years ago, and which were found to be clouds at such great altitudes above the earth's surface (upwards of fifty miles high) that they received the sunlight long after or before the ordinary clouds. The observations of O. Jesse were printed in the *Astronomische Nachrichten*, Bd. 121, pp. 73, 111; Bd. 130, p. 425; Bd. 133, p. 131; Bd. 140, p. 161. In *A. N.*, Bd. 140 (No. 3347), he gives a long list of altitudes, determined by photography, which range from 81 km. to 87 km. The mean value given by the observations from 1885 to 1891 was 82 km. (52 miles). These clouds were seen in the northern hemisphere only near the time of the summer solstice. In the southern hemisphere they were seen at the opposite season. From his papers it is clear that these sunlit clouds were in no way related to the present subject, and I only mention them to forestall any suggestion that they were similar to the ones seen by me. The objects to be described here were apparently at the altitude of the ordinary higher clouds. They have been seen in all parts of the sky and at all hours of the night. In a paper on the aurora¹ I have previously called attention to the frequent luminous condition of the sky at night. This feature long ago impressed itself upon me. Indeed any one who has spent much time under the open sky hunting comets, etc., will have been forcibly impressed with this peculiarity. In most cases this illumination has been due evidently to a diffusion of the

¹ " *Astrophysical Journal*, 31, April, 1910.

general star light, perhaps by moisture in the air. This latter condition is present as a whitening of the sky, which gives it a "milky" appearance. At other times the sky is more or less feebly luminous, but the luminosity is different from the other condition and is evidently not due to a diffusion of star light. In reality the sky seems to be self-luminous. Sometimes the whole sky has this appearance, and at other times a large portion only. At times the illumination is so great that the face of an ordinary watch can be read with no other light than that of the sky. It is indeed seldom that the sky is rich and dark. In any determination of the total amount of the light of the sky the results must be uncertain because of the great changes that so often take place in the amount of the illumination. The self-luminous condition frequently occurs when no ordinary indications of an aurora are present. It is, nevertheless, doubtless of an auroral nature, for Professor Campbell has shown that the spectrum of the aurora is essentially always present on a clear dark night. (*Astrophysical Journal*, 2, August, 1895, p. 162.)

I have given an account² of the remarkable pulsating clouds of light that are seen here occasionally and which usually, but not always, have an easterly motion—generally southeast. They are mostly confined to the northern half of the heavens. There is another phenomenon that has been visible on a number of nights of last year, and also in the present year, of which I have seen no record. This consists usually of long strips of diffused luminous haze. I believe that this is really ordinary haze, which for some reason becomes self-luminous. It is not confined to any particular region of the sky nor to any hour of the night. It always has a slow drifting motion among the stars. This motion is comparable with that of the ordinary hazy streaky clouds that are often seen in the daytime. They are usually straight and diffused and as much as 50° or more in length and 3° or 4° or more in width. In some cases they are as bright, or nearly as bright, as the average portions of the Milky Way—that is, they are decidedly noticeable when one's attention is called to them. They apparently are about as transparent as ordinary haze. Sometimes, when seen near the horizon, where

² *Astrophysical Journal*, 31, April, 1910, p. 210, etc.

they may be quite broad, they have strongly suggested the "dawn" or glow that precedes a bright moonrise. Their luminosity is uniformly steady.

The reason I speak of this matter as haze, and the reason I think it is only ordinary haze made self-luminous, is because on one occasion I watched a mass of it in the northwestern sky which was slowly drifting northerly in the region of the great "dipper" of Ursa Major as daylight came on. These hazy luminous strips had been visible all the latter part of the night—new strips coming and going slowly, sometimes several being seen at once. As daylight killed them out I noticed, when the light had increased sufficiently, that there were strips of ordinary haze exactly the same in form and motion and occupying the same region of the sky. I am sure they were the same masses that had appeared luminous on the night sky. My impression, therefore, is that these hazy luminous strips were only the ordinary haze which had for some reason become self-luminous. I am specially certain that these masses are not luminous as a result of any great altitude which might bring them within reach of the sun's light, for they were frequently seen in such positions that the sun's rays could never reach them. The sun or moon, therefore, had nothing to do with their illumination. It is also needless to say that they are not related to the pulsating auroral clouds which I have previously mentioned.

I have not noticed this luminous haze in former years, though it may have been present, and did it not seem unreasonable, one might suspect some relation between this condition of the atmosphere and the possible passage of the earth through a portion of the tail of Halley's comet on 1910, May 19.

I will give here the observations which I have obtained of these singular features. It seems to me that these objects should be observed and a record made of the times of their visibility and their motion, etc. It would be valuable to have records of them from different stations to see if their luminosity is due to some general condition of the earth's atmosphere at the time. It is not probable that this luminosity is in any way due to local conditions. In the records here given, it is possible that on one or two occasions an

aurora was also present, but I have tried to confine the accounts to what I have called, and believe to be, self-luminous haze. They were not seen previous to June 7, 1910.

THE OBSERVATIONS.

1910, June 7d 13 h om. These diffused luminous masses were seen in different parts of the sky. They were specially noticeable near the southern horizon where the appearance was that of a definite whitish light stretching along above the horizon for a considerable distance. Long bands of this matter were parallel with the southern horizon and above Antares. In the east a long strip 3° or 4° wide stretched from α Pegasi to α Andromedæ and beyond. This moved slowly eastward. At 13h 30m another was passing through the bowl of the great "dipper" in the northwest with a slow easterly motion. A very broad one was situated about 15° – 20° from the zenith to the west. They were about as bright as the Milky Way in Cygnus. I waited until near sunrise, and could then see a long mass of ordinary haze, reddish with sunlight, occupying the position of one of the strips that was seen near the bowl of the "dipper," which had been visible as a luminous mass until the dawn had killed it out. There were other strips and masses of haze at different points in the sky when the sun rose. I think it was these streaks and patches of diffused haze that were luminous during the night. They appeared as ordinary haze clouds in daylight. During the entire night there had been no ordinary trace of aurora.

June 9. Though they were looked for several times none was seen until about 10h 30m or 11h om. At 11h 25m a long broad hazy streak, as bright as the Milky Way in Cassiopeiæ was seen in the northwest. The lower end was in the "sickle" of Leo near the horizon. Its upper end was 15° below the polar star. From a sketch at 11h 25m the following points were taken which were involved in the hazy strip:

$$\begin{array}{ll} \alpha \text{ 10h 5m} & \delta + 21^{\circ}.5, \\ \alpha \text{ 9 5} & \delta + 49. \end{array}$$

It extended beyond this latter point for quite a distance—roughly to about

$$\alpha \text{ 7h om} \quad \delta + 67^{\circ}.$$

The stars were visible through it where it passed over them. The motion was slowly to the northwest among the stars. Its width was 5° . At 12h om a similar band passed over the "dipper" parallel to the first one, evidently moving in the same direction. The first one at this time had either disappeared or was too near the horizon to be seen. At midnight I could read the time by my watch with only the illumination from the sky, which was milky and whitish or luminous.

June 10d 10h 45m. A long strip passed through Polaris and 5° below the bowl of the "dipper." Its motion was towards the north by east horizon. 11h om a great number of luminous masses were scattered over the western sky (and extending to the south) to nearly as high as the zenith. These were mostly parallel strips with some irregular masses. They extended from the horizon and seemed to diverge upwards.

September 29. The sky was irregularly covered everywhere with a kind of luminous haze which occurred in great areas and in strips, with a few clear spaces between which were relatively dark. They were more or less conspicuous. At 8h 25m a diffused luminous band stretched from Corona Borealis to the southwest horizon—nearly north and south. This continued northerly nearly to the pole and was diffused to the west. In the south and southeast for 20° above Fomalhaut to α Ceti was the upper edge of a luminous mass of haze covering the southeast sky to the horizon. Other diffused areas of this matter were visible at different points over the sky. The whole sky was more or less luminous, but less noticeable than the regions described above. By 8h 50m the broad luminous strip at Corona Borealis had drifted a little east among the stars, but it seemed to go westward with them. At 11h 10m a watch could be read by the light of the sky. This was one of the brightest of the luminous nights that I have seen. The matter seemed to be only ordinary haze but luminous for some reason. There was no trace of aurora. The sky on which the luminous haze was seen was, at this time, brightened with a pale uniform illumination covering the entire heavens and nearly blotting out the Milky Way. These masses had very little motion. The sky was too luminous for long exposures with a portrait lens.

September 30. At 9h 15m for 10° above the east by north horizon a broad luminous band 50° long was seen just above and involving Aldebaran. It stretched to the south of the east point and in brightness resembled the appearance produced by the moon just before it rises. The light was soft, yet conspicuous. At 10h 10m under Capella was a large soft diffused light—diffusing to the east and beyond. This light was steady with no fluctuations. Nothing of a similar nature was visible in the north or elsewhere. The sky was dull and more or less luminous. At 10h 55m the illumination extended half way up to Aldebaran and the sky near the horizon was luminous like moonrise. This extended from 25° south of east to nearly due north, rising much higher under Capella—a very soft and steady illumination. 12h 0m. The illumination was feeble and diffused. At 12h 30m it was very feeble and mostly in the northeast—scarcely noticeable. At this time dark smeary haze was visible all over the south. No evidence of an ordinary aurora was seen during the night. The sky was luminous all over, but not so much so as on the twenty-ninth.

October 1. There was a bright aurora.

October 2, 8h 0m. A pale illumination was seen in the low north and also in the low east. The effect was probably auroral.

October 6. The night was more or less luminous and misty.

October 28. There was a luminous sky at night.

October 30, 13h 0m. The night was very luminous with fully as much light as would be caused by a one quarter full moon. The Milky Way was scarcely visible. Watch easily read by the glow at 14h 0m. At 15h and 15h 30m a luminous haze covered all the low northern sky as high as half way to the pole. This was not strong and did not look like an aurora. It seemed simply to be luminous haze.

November 1, 12h 15m. The sky was remarkably luminous everywhere. In the north from the horizon to halfway to the pole the sky appeared more luminous than elsewhere. No trace of an arch. The illumination did not look like that from an aurora, but at 15h 30m a strong auroral arch had formed.

November 10, 12h 0m. There was a great amount of luminous

haze in the north and northwest. At 15h om a large mass 10° high was visible in the northwest. Later there was a long diffused strip, 10° wide, which cut the Milky Way at right angles 20° above α Cygni. It was 40° or 50° in length and did not fluctuate. Its appearance was that of luminous haze. Below it was a region of luminous haze that extended to the north.

1911, February 28, 15h 30m. For 20° to 25° altitude all over the east and northeast the sky was luminous with a soft auroral light. There was no arch or intensification near the usual place for an aurora. This was not due to the presence of the Milky Way at that point.

March 2, 8h 10m. A long mass of luminous haze 6° or 8° broad was visible below β Leonis in the east. It diffused down to the northeast horizon. It seemed to be brighter at times, but there were no certain fluctuations of its light. It was not bright. 8h 50m. The region of luminous haze was passing over Arcturus and moving towards the east horizon. It was nearly horizontal and 30° long with the north end the lowest. 10h 45m. A long mass of luminous haze was visible one half way from Spica to the southeast horizon. It extended south as far as Corvus and inclined to the southeast horizon. It was quite bright and steady in its light. All of the southeastern sky strongly resembled the glow from an expected moonrise. 11h 35m. A strong glow from the southeast horizon extended up to 15° or 20° above Jupiter—like a strong moonrise—all along from the east to the south and diffusing upward. It was conspicuously strong. By this time the sky was increasing in luminosity. In the meantime there had been no trace of aurora during the night. These were the first of the luminous masses of haze that I had seen for a long time, except that of February 28, when it appeared near the northeast horizon.

Since the above observations I have not seen any of this luminous haze on the few clear nights that we have had in the absence of the moon.

YERKES OBSERVATORY,

April 4, 1911.

NOTE.

Since this paper was in type Mr. C. F. Talman, Librarian of the Weather Bureau at Washington, through Dr. W. J. Humphreys, has called my attention to a paper, No. 22, of the Publications of the Astronomical Laboratory at Gröningen, "On the Brightness of the Sky and the Total Amount of Starlight" by L. Yntema. Dr. Yntema calls attention to the frequent luminous condition of the sky and its effect on determinations of the amount of starlight. In section 14 of his paper, which is devoted to earthlight, he gives numerous records of this illumination. There does not appear to be any direct reference, however, to the main features of my paper—the luminous hazy strips and masses.

May 15, 1911.